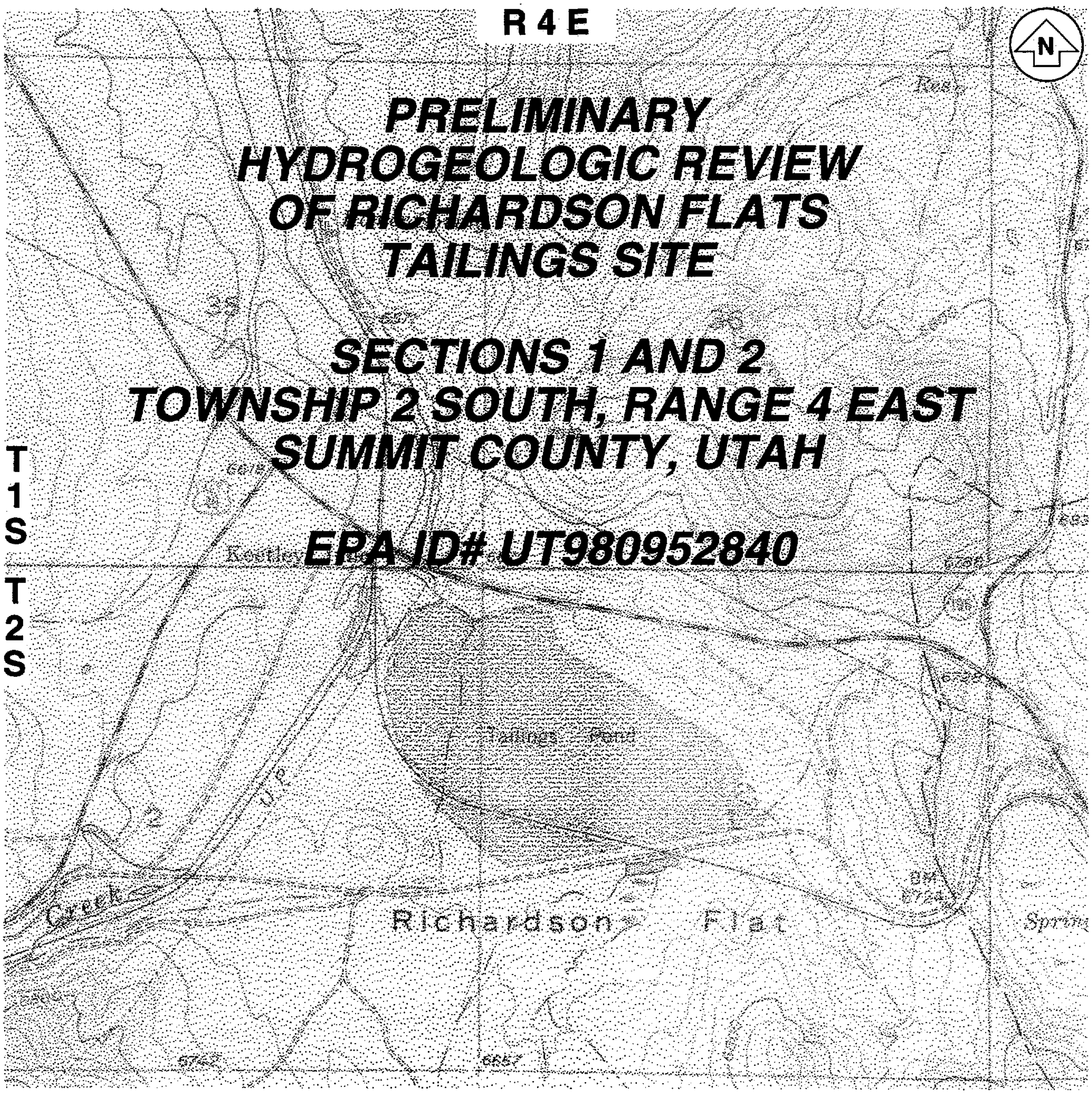
PRELIMINARY HYDROGEOLOGIC REVIEW OF RICHARDSON FLATS TAILINGS SITE

SECTIONS 1 AND 2
TOWNSHIP 2 SOUTH, RANGE 4 EAST
SUMMIT COUNTY, UTAH

EPA ID# UT980952840



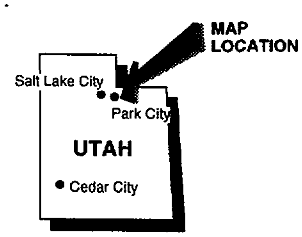
Base map adapted from U.S. Geological Survey Park City East, Utah 7.5 Minute Topographic Map, 1955

0 — 1 MILE

SCALE

MARCH, 1999

PREPARED BY
WESTON ENGINEERING, INC.



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SECTIONS 1 AND 2
TOWNSHIP 2 SOUTH, RANGE 4 EAST
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EPA ID# UT980952840

March 23, 1999

Prepared For

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PRELIMINARY HYDROGEOLOGIC REVIEW OF RICHARDSON FLATS TAILINGS SITE

STATEMENT OF THE PROBLEM

Richardson Flats covers an area encompassing approximately 700 acres in a small valley located about 1.5 miles northeast of Park City, Utah. The Environmental Protection Agency (EPA) placed the site on the CERCLIS listing as EPA ID# UT980952840 and nominated the site to the National Priorities List (NPL) in 1992 due to the presence of potentially hazardous substances associated with disposal of mill tailings on approximately 160 acres; however, the site has not been listed on the NPL. An abundance of investigative work was completed by design consultants working on behalf of various mining companies to design the tailings impoundment during the 1970s and early 1980s. EPA contractors commenced reconnaissance-level environmental investigations in support of the Hazard Ranking Scoring (HRS) in the 1980s. However, prior to 1999, little work was conducted on developing a hydrogeologic conceptual model using the readily-available information.

PURPOSE AND SCOPE OF REPORT

The purpose of this report is to present a conceptual hydrogeologic model of the Richardson Flats site focusing on the occurrence and movement of groundwater. The mutually-agreed upon scope of work between LeBOEUF, LAMB, GREENE & MacRAE, L.L.P. and Weston Engineering, Inc. (WESTON) involved the following tasks:

- Perform initial field measurements and observations;
- Compile available historic and current data;
- Develop initial conceptual model of groundwater occurrence, interaction with surface water, and direction and magnitude of hydraulic gradients and groundwater flow;
- Identify data gaps and locations where additional information is needed;
- Establish new data collection points, if needed;
- Integrate new information with existing information;
- Refine conceptual hydrogeologic model; and
- Prepare this summary report.

This summary report is based on geologic and hydrologic data contained in published and unpublished reports, as well as field observations made during a confirmation drilling and hydrogeologic data collection program completed in January and February, 1999. Water quality issues are not a part of this investigation.

HYDROGEOLOGIC SETTING OF RICHARDSON FLATS

Location

Richardson Flats is located in Sections 1 and 2, Township 2 South, Range 4 East in Summit County, Utah. The tailings impoundment is located within a few hundred feet of Silver Creek, a perennial stream draining the Park City area where other historic tailings ponds were located (see Mason, 1989).

Structural Geology

While the Richardson Flat tailings pond is located within a complex fold and thrust belt later intruded and overlain by volcanic rocks, mapping by Bromfield and Crittenden (1971) place no faults near the site (see Geologic Map Inset - Plate I). Examination of low-altitude aerial photography indicates that the volcanic rocks near the site are fractured; linear ridges in the surface topography indicate potential faults near Homer Spring and along a northeast-southwest trending ridge located east of Keetley Junction.

Stratigraphic Setting Based on Historic Data

EPA records indicate that the Richardson Flat tailings pond was apparently constructed during 1953 on alluvium and colluvium derived from Silver Creek and the attendant subsidiary drainages. The alluvium and colluvium is approximately 30 to 50 feet thick on the basis of logs of geotechnical borings and studies completed as part of the improvements to the reconstruction of the tailings pond in the 1970s, in addition to the logs of monitoring wells installed to assess groundwater impacts in the 1980s (see Dames & Moore, 1973; 1974; 1980; and Ecology and Environment, 1985). While the data distribution is less than ideal, the available information indicated the following materials comprise the stratigraphy of the alluvial and colluvial debris:

- Two-to-five feet of soft, organic and clay-rich topsoil;
- One-to-30 feet of various mixtures of fine-grained silt and clay;
- Four feet of sand and gravel; and
- Variable thickness of highly-weathered volcanic breccia composed of relatively soft, tight, sandy and silty clay grading to moderately hard, slightly to moderately fractured volcanic rocks.

Recent exploratory drilling by the Park City Municipal Corporation at a site located approximately one mile northwest of the tailings pond determined that the underlying Keetley volcanic rocks may be more than 1,000 feet thick (see Geologic Map Inset - Plate I). Mapping by Bromfield and Crittenden (1971) indicate that well-indurated Mesozoic and Paleozoic limestones, sandstones, and shales may underlie portions of the Richardson Flats area. Holmes and others (1986) report that some of these rock units serve as aquifers where saturated and permeable.

The tailings overlie the topsoil composing the original surface grade. The dark-colored, clay-rich organic topsoil was consistently logged by the various geotechnical and environmental investigations, and serves as the best horizon to correlate between the widely-spaced borings. The pre-tailings topography of the area was integrated with the test pits located within the tailings pond to estimate the thickness of the tailings. These data indicate that the thickness of the tailings is approximately 10 to 18 feet and perhaps thicker along the northern boundary.

Hydrogeologic Overview Based on Historic Data

Examination of the historic boring and well logs in the area indicated that at least four shallow groundwater systems may be found in the Richardson Flat area:

- Shallow alluvium with possibly a perched water table;
- Deeper alluvium composed of confined sand and gravel aquifer(s);
- The underlying and adjacent fractured Keetley volcanic rocks; and
- The impounded tailings.

inconsistent

Alluvium. The boring log for the upgradient monitoring well installed by Ecology and Environment (1985; see RT-1 in Attachment No. 1) reveals that water was first encountered at a depth of 17 feet within primarily red-brown clay and gravely sand; deeper drilling encountered yellow-gray clay from 15 to 23 feet, red-brown sandy clay from 23 to 34 feet, and gravel yielding 10 to 15 gallons per minute (gpm) from 34 to 38 feet. Following completion of the boring as a monitoring well with screens set across both intervals where water was reported, the static water level was found at 9 feet below ground surface. Because the post-completion static water level was higher than the "first" water, one reasonable interpretation of the limited post-completion data is that (1) the boring initially encountered a water table aquifer; (2) deeper drilling encountered a sand and gravel zone under confined conditions; and (3) the completed well connected these two previously separate aquifers.

Keetley Volcanics. The underlying weathered and unweathered Keetley volcanic rocks have low intrinsic permeabilities and yield low quantities of groundwater to wells and springs. Dames & Moore (1974) report that the low hills located north of the impounded tailings are covered by dark brown, stiff, clay of varying thickness; three to four feet of this material was encountered in Test Pit Nos. 20 and 21 (see Plate I). Dames & Moore (1974) further report the clayey material grades with some sand and dense clayey sand indicative of highly weathered volcanic breccia.

Park City Municipal Corporation recently installed a test well in the southeast corner of Section 34, Township 1 South, Range 4 East, approximately one mile northwest of the tailings pond. The well was spudded on the weathered Keetley Volcanics with the underlying Thaynes Limestone as the targeted aquifer. However, the Thaynes Limestone was not encountered at the final drilled depth of 1,000 feet. While the exploratory boring developed water from the fractures in the unweathered Keetley volcanic rocks, the quantity of water that could be reasonably developed from the Keetley Volcanics at this location was between 100 to 200 gpm with long-term drawdown estimated at 250 to 300 feet (specific capacity = 0.33 to 0.4 gpm per foot of drawdown (gpm/ft) or a transmissivity of 30 to 50 ft^2/day). This yield was considerably less than the quantity desired by Park City for a municipal water supply, and the well remains unused (see Hansen, Allen & Luce, 1996).

No water quality samples were collected from this well for analysis of potability; however, Hansen, Allen & Luce (1996) imply that the water quality may be suitable for short-term irrigation. Nearby springs also discharge water at approximately four to eight gpm with low total dissolved solids (TDS) from these volcanic rocks (Holmes and others, 1986; Downhour and Brooks, 1996).

Impounded Tailings. Based on the test boring installed by Ecology and Environment (1985; see RT-2 in Attachment No. 1), the tailings were partially saturated. Water level measurements made during the 1973 and 1974 design phases of the tailings pond development, coupled with the 1985 water level measurements, indicated that the lower 15 feet of the tailings were saturated. Cursory examination of the historic water level data indicated that the groundwater within the tailings flowed from southeast to northwest under a gentle hydraulic gradient (0.0031).

PRELIMINARY CONCLUSIONS BASED ON AVAILABLE HYDROGEOLOGIC DATA

On the basis of the historic records, uncertainty existed regarding (1) the degree of saturation within the tailings; (2) the hydraulic connection between water stored in the tailings and the shallow alluvial aquifer(s); (3) the hydrologic characteristics of the shallow aquifer(s) with respect to water table or confined conditions; (4) the hydraulic connection between the shallow aquifer(s) and Silver Creek; and (5) the hydraulic gradient in the shallow aquifer(s) between the historic landfill investigated by Ecology and Environment (1993) and the tailings embankment (see Plate I for location of historic landfill monitoring wells).

Supplemental work was conducted during early 1999 to build upon rather than duplicate the previous work efforts. This work included:

- Installation of piezometers within the tailings pond to determine whether the tailings remain partially saturated;

- Installation of piezometers outside the tailings pond to compare and contrast the hydraulic head across the embankment to evaluate the degree of hydraulic connection, if any, between the impounded tailings and shallow aquifer(s), and between Silver Creek and the shallow aquifer(s);

- Confirmation of the apparent upward hydraulic gradient indicated by the upgradient monitoring well (RT-1) installed by Ecology and Environment (1985); and

- Better characterization of the hydrogeology between the historic landfill and the downgradient tailings embankment.

SUPPLEMENTAL SOIL SAMPLING AND WATER LEVEL MEASUREMENT PROGRAM

Drilling and Piezometer Installation

Geotechnical borings and small-diameter piezometers were installed using direct-push and hollow stem auger methods during the week of January 25, 1999. Plate I depicts the locations of the supplemental drilling locations, in addition to the numerous historic test pits, borings, and existing monitoring wells in and near the tailings pond. Note the piezometer numbering system for the recent drilling program follows that employed by Ecology and Environment (1985). Ecology and Environment (1985) designated their hydraulically upgradient well as RT-1 and the boring within the tailings as RT-2. Other borings installed during this investigation were labeled in sequence of installation beginning with RT-3. Shallow borings designed to test the presence of shallow aquifer(s) were designated with the letter "A" following the boring number and the deeper borings designed to test for deeper aquifer(s) were designated with a letter "B". The lithologic logs and a description of the as-built configuration for the individual piezometers can be found in Attachment No. 1.

The supplemental lithologic information indicated the following materials, from top to bottom, comprise the stratigraphy of the tailings pond and the underlying and adjacent alluvial and colluvial debris:

- Clay-rich artificial fill derived from the burrow area depicted on Plate I and capping the impounded tailings approaches one foot in thickness;
- Fine-grained sand tailings approximately 16 to 18 feet thick in the central portion of the tailings pond, and perhaps thicker along the northern boundary;
- Two-to-five feet of clay-rich organic pre-tailings topsoil found in every test pit and boring in the tailings;
- Approximately 15 feet of reddish-brown mixtures of silt and clay;
- Two-to-six feet of reddish-brown gravelly clay;
- Two-to-ten feet of reddish-brown to yellow-brown mixtures of silt and clay; and
- Two-to-ten feet of clayey sand and gravel.

Plate I provides conceptual hydrogeologic cross sections summarizing the local distribution of the various lithologies by integrating the historic test pits, borings, and supplemental borings.

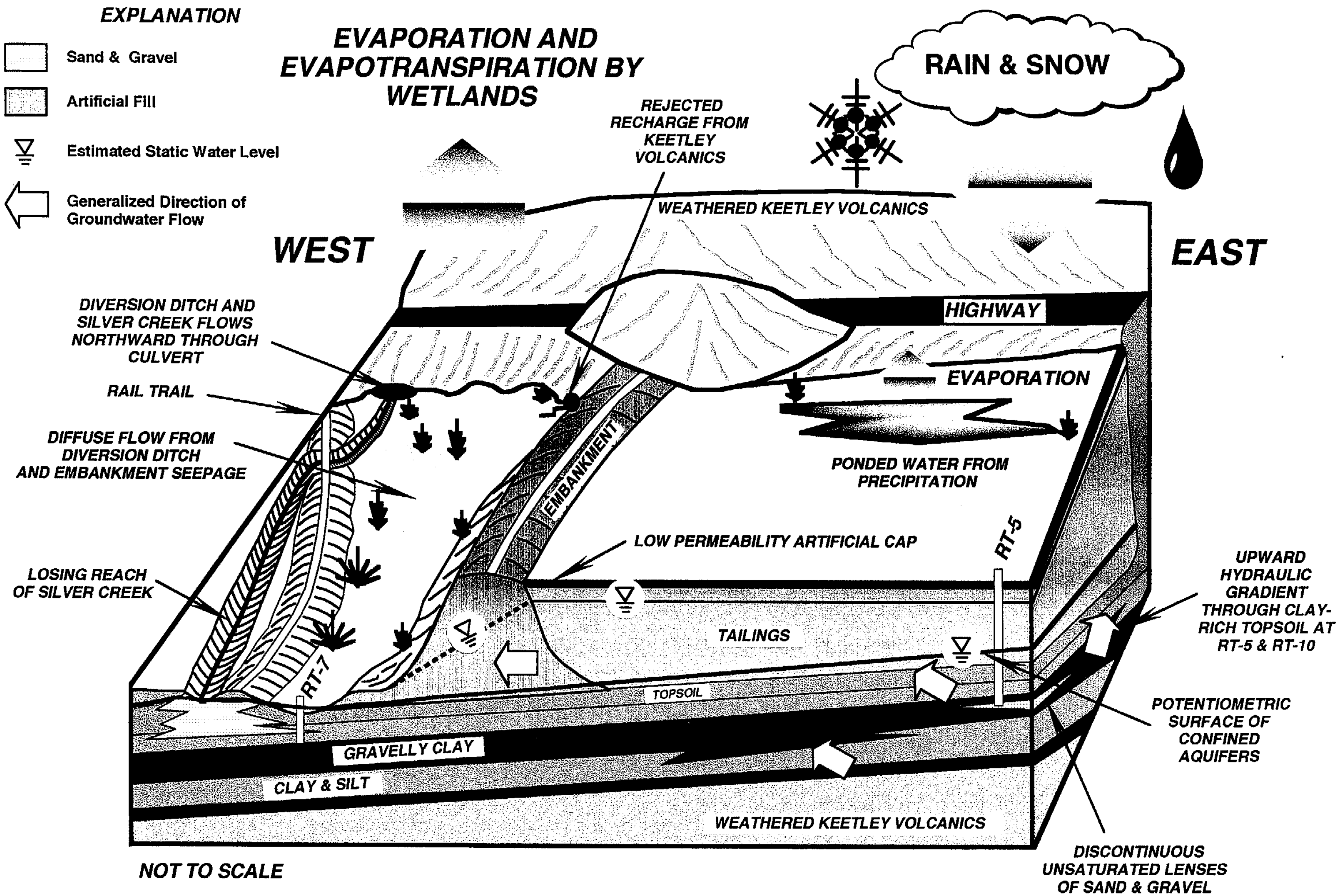
Clay Mineralogy Analysis

Knowledge of the clay mineralogy in fine-grained soils provides information on the engineering behavior of soils and potential attenuation capacity for certain contaminants. Selected soil samples from boring RT-5 were analyzed using X-ray diffraction (XRD) techniques to better characterize the mineralogy of the fine-grained sediments overlying and underlying the tailings. Samples from boring RT-5 were selected because the materials encountered included the best representation of (1) the artificial cap overlying the tailings, (2) the clay-rich organic topsoil found beneath the tailings, and (3) the clay-rich soils found beneath the top soils which created confined conditions in the deeper saturated soils. A discussion on sample preparation methods and copies of the various figures referenced below can be found in Attachment No. 2. The rectangular boxes beneath the individual XRD traces are XRD peaks for standard patterns prepared by the Joint Committee on Powder Diffraction Standards (JCPDS) which can be accessed by the computer serving the XRD device.

Artificial Cap. Material for the artificial cap was derived from the weathered volcanic rocks on the low hills north of the tailings impoundment. XRD results for the sample of the artificial fill capping the tailings found from 0 to 0.7 feet closely match the XRD peaks for illite and kaolinite. Kaolinite is the most prevalent clay mineral and is stable with little tendency for volume change when exposed to water. Illite is generally more plastic than kaolinite and does not expand when exposed to water.

Color Map(s)

The following map(s) contains color photographic imagery that the scanned image cannot capture to the full quality of the source document.



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HYDROGEOLOGIC REVIEW
RICHARDSON FLATS TAILINGS SITE
PRELIMINARY CONCEPTUAL MODEL OF SHALLOW AQUIFER GROUNDWATER FLOW SYSTEM
FIGURE 1

Native Soil Beneath Tailings. The sample of the clay-rich organic topsoil found below the tailings at approximately 11 feet in depth, in addition to the underlying sandy clay found between 13 and 14 feet, closely match the XRD peaks for the clay mineral sepiolite. The characteristic peak at a d-spacing of 12Å does not match any other "simple" clay minerals. However, it is possible that the clay identified as "sepiolite" is in fact a rather ill-defined mixed-layer clay mineral (mixed mica and illite or smectite, for example) which can be found in relatively immature soils on granitic bedrock. The distinction cannot be made without further analysis. Smectite readily absorbs water between clay layers yielding large volume changes because of this property. Likewise, because of the weak bond between layers, various contaminants can be absorbed by the mixed-layered clays.

Groundwater Occurrence and Circulation Model

Because of the fine-grained texture of the shallow aquifers, the water levels in the recently-installed piezometers were allowed to stabilize for at least four days following installation prior to measurement. A summary of the water level measurements can be found both on the individual boring logs, and in the table provided on Plate I. The point of reference for all measurements is the ground surface next to the individual piezometer or well. Elevations of selected water surface locations along Silver Creek and the diversion ditch located south of the tailings pond were also surveyed for points of reference, as indicated on Plate I.

The recent water level measurements in the local wells and piezometers indicate that the three principal shallow groundwater systems underlying the Richardson Flats area are as follows:

- Shallow alluvium along Silver Creek under unconfined conditions;
- Deeper alluvium and colluvium composed of confined sand and gravel aquifer(s) mixed with abundant fine-grained materials; and
- The impounded tailings under unconfined conditions.

Confined Aquifers. Groundwater stored in the saturated and permeable strata comprising the shallow aquifers adjacent to the tailings pond is found under confined conditions in at least three discrete intervals. Examination of the hydrogeologic cross section A-A' depicted on Plate I reveals the first water bearing interval is found at approximately 15 to 20 feet in depth. The deeper water bearing intervals are found between 25 to 35 feet in depth. Because the water levels in piezometers RT-1A/B and RT-8A/B rise above the top of the identified aquifers, the low permeability fine-grained silt and clay found overlying and layered between the shallow and deeper aquifers serve as effective confining strata.

The hydraulic communication between the shallow and deeper water bearing intervals appears to be poor. Examination of the water level elevations measured in February, 1999 and summarized on the table on Plate I indicates nearly 0.4 feet of head difference between the shallow and deeper aquifers in the vicinity of RT-1A/B. The hydraulic gradient between these aquifers is downward at this location. Likewise, the water levels in the piezometer series RT-8A/B indicates a similar hydrologic relationship with the exception that the hydraulic gradient between the deeper and shallow aquifer is upward (see hydrogeologic cross section A-A'). Mason (1989) reported a downward component of groundwater flow similar to that observed at Richardson Flats in the unconfined to semi-confined unconsolidated valley fill aquifer(s) underlying the Silver Creek tailings site near Prospector Square.

Groundwater in Impounded Tailings. The depth to water below the artificial fill cap on the impounded tailings is approximately three to five feet (see cross sections A-A' and B-B' on Plate I). Examination of section B-B' reveals some uncertainty regarding the free water surface in the tailings pond because the tailings and underlying materials open to piezometer RT-4 are unsaturated. Likewise, the tailings encountered in boring RT-5 are also unsaturated. For example, the boring encountered unsaturated tailings to a depth of 10.8 feet and was completed in silty sand and sandy clay materials to a depth of two feet below the tailings-topsoil interface (see Boring Logs in Attachment No. 1). However, the water level in piezometer RT-5 is found at an elevation of approximately two feet higher than the elevation of the water levels in the tailings piezometers RT-3 and RT-6.

While the source of the water stored in the tailings remains unknown, reasons for the unsaturated tailings include (1) evaporation prior to capping with artificial fill, (2) the artificial fill cap is composed of low permeability clay-rich material which effectively precludes downward flow of ponded surface water, (3) low-rate leakage across the tailings embankment, and (4) combinations of all of the above. Water level measurements collected during March, 1999 indicate that water levels rose in all piezometers on the order of one to two feet (see table on Plate I). Mason (1989) observed the water levels varying seasonally in monitoring wells completed in the unconsolidated fill near the Silver Creek tailings site, with the season high occurring during March and April. The effects of snow melt and storm water collecting in the tailings pond requires additional study.

Hydrologic Role of Clay-rich Organic Topsoil. The anomalously high water level elevation in piezometer RT-5 is attributed to the hydrologic confining properties of the clay-rich organic topsoil. Examination of the boring log for RT-5 indicates the original topsoil is found at 10.8 feet in depth and the overlying tailings are damp. Deeper drilling found the topsoil damp, becoming increasingly saturated with depth. The underlying silty sand is saturated. The sandy clay beneath the silty sand is moist, yet the deeper gravelly sand found at 14 feet is only damp to moist. The depth to water at RT-5 is 7.3 feet below the ground surface, approximately 3.5 feet above the interface between the unsaturated tailings and the original topsoil.

A hydrologic relationship similar to that defined at piezometer RT-5 is found at piezometer RT-10 located approximately 2,900 feet south of the impounded tailings (see Plate I). The initial 3.5 feet of fine-grained, organic-rich clay and silt soils are partially saturated. The silty sand encountered below 3.5 feet is saturated, and the depth to water in the completed piezometer is 1.1 feet below ground surface. All of these data indicate the topsoil is a low permeability confining layer overlying the shallow aquifers and underlying the tailings at the Richardson Flats site.

Volcanic Rocks. While the underlying and adjacent weathered and unweathered Keetley volcanic rocks may constitute a deeper aquifer, no piezometers were installed in these rocks for the supplemental investigation because the supplemental soil sampling and water level information indicated the shallower aquifers were separated by low permeability confining strata. For example, the artificial fill capping the impounded tailings was derived from the burrow area depicted on Plate I. Percolation tests completed on selected samples of the artificial fill indicated low permeabilities (see Plate I). Likewise, Dames & Moore (1973) indicated that while the permeability of the unweathered and fractured volcanic rocks would be greater at depth, the weathered surface of the volcanic rocks would nearly eliminate seepage to greater depths. An aquifer interference test designed to determine the possible effects of pumping a large capacity well serving Park City Municipal Corporation which was completed in fractured carbonate rocks underlying the unconsolidated sediments along Silver Creek confirmed this apparent lack of hydraulic communication between the shallow and deep alluvial aquifer systems near the Silver Creek tailings site (see Mason, 1989, p. 33)

Generalized Groundwater Flow Model. Examination of the potentiometric surface elevations depicted on Plate I indicates that groundwater flows from areas of higher hydraulic head located south of the tailings pond northward to areas of lower hydraulic head. On the basis of the water level measurements of Silver Creek located west of the impounded tailings and the water level measured in piezometer RT-7, the water surface in Silver Creek is found at a higher elevation than in the adjacent low area. Likewise, groundwater stored in the alluvium at piezometer RT-9 is also found at a higher elevation than the water surface of the pond located along the diversion ditch (see Plate I). Groundwater stored in the shallower aquifers overlain by the clay-rich organic topsoil apparently flows towards the diversion ditch as indicated by the elevations of the potentiometric surface measured in piezometers RT-8 A/B and RT-5.

On the basis of the historic and supplemental geologic and hydrologic data, a hydrogeologic conceptual model of the Richardson Flats area is depicted on Figure 1. Precipitation and snow melt serve as: (1) the principal sources of recharge to the groundwater system; (2) perennial flows to Silver Creek; and (3) surface water ponding on the impounded tailings. The shallow aquifers are primarily confined by low permeability clay and silt layers. The clay-rich organic topsoil also serves as a confining layer. On the basis of stream flow measurements by Holmes and others (1986) and surveyed water level measurements made during this study, unconfined aquifers occur locally within the alluvium along Silver Creek where the creek serves as both a gaining and a losing stream. Groundwater flow in the shallow aquifers is primarily upward in the vicinity of the tailings impoundment and directed towards the diversion ditch and Silver Creek, both serving as local hydraulic sinks. Discharge to low areas occurs along the toe of the embankment as water stored in the impounded area seeps through the embankment as originally designed as an engineered structure. Seepage also apparently occurs along the northern extent of the embankment which may reflect rejected recharge from the weathered volcanic rocks or water seepage from the impounded tailings. As indicated in the following section, the bulk of the seepage across the tailings embankment as well as the diffuse flow from the diversion ditch completes the hydrologic cycle by evaporation or evapotranspiration through consumptive use by the wetlands located in the low area between the tailings embankment and Silver Creek.

ESTIMATES OF GROUNDWATER DISCHARGE ACROSS TAILINGS EMBANKMENT

On the basis of the February, 1999 water level data collected in the piezometers completed within the impounded tailings and comparing these data to the water levels in the embankment wells, the difference in hydraulic head across the embankment approaches 17 feet. Integrating the observed difference in hydraulic head with the assumption that the footprint of the embankment approaches 400 feet, yields a hydraulic gradient of 0.0425 (see Plate I, section B-B'). Assuming that the water level data collected in February, 1999 within the impounded tailings reasonably reflects current conditions, first-order approximations of seepage rates across the tailings embankment can be made with permeability data derived from percolation tests completed by Dames & Moore (1973; 1974; 1980) and Applied Geotechnical Engineering Consultants, Inc. (1999). A summary of the permeability data for various earth materials located in and near the tailings embankment is provided in Table I.

TABLE I
HYDRAULIC CONDUCTIVITY MEASUREMENTS OF RICHARDSON FLATS MATERIALS
SUMMIT COUNTY, UTAH

Media	Sample Location	Hydraulic Conductivity (ft/year)
Artificial Fill Cap	See Plate I	0.031 to 0.072*
Natural Soil	TP-8**; UPCMC Well No. 3***	0.001 to 5**
Rock	UPCMC Well Nos. 1,2, 3	0.6 to 1**
Tailings and Slimes	TP-1,2,3,4	3 to 4,000**
Recompacted Soil	TP-20	1**
Recompacted Tailings	TP-17	20 to 45**
Recompacted Gravel Pit Material	Near TP-6	75 to 82**

* Reported values represent unit conversions of data reported by AGEC (1999) listed in Attachment 3.
** Test Pit Locations and data from Dames & Moore (1973; 1974) - See Plate I.
*** UPCMC = United Park City Mines Co. Well Numbering System - See Insert on Plate No. 1.

A range of values were incorporated into the analysis because Dames & Moore (1980) reported the following conditions: (1) the embankment was not constructed using engineered fill; (2) the internal zoning of the embankment was not constructed as recommended by the design engineer; (3) the main embankment and adjoining dike were constructed largely of silty sand and gravel; and (4) the southeastern portion of the embankment was constructed of clay and gravelly clay derived from areas near Highway 40 located north of the impounded tailings. Using the best available estimates of hydraulic gradients, the seepage across the tailings embankment can be estimated using the Darcy equation:

$$q=kia$$

where **q** is the Darcy flux or volumetric flow rate per unit area per unit time; **k** is the saturated hydraulic conductivity; **a** = area; and **i** is the hydraulic head gradient. Substitution of the variables into the Darcy equation yields estimates of seepage across the tailings embankment as summarized in Table II.

Based on these simple calculations, reasonable estimates of the seepage rates across the embankment face range from approximately 0.6 to 63 gallons per day. Use of the higher end of the range for the hydraulic conductivity of the tailings and slimes to estimate seepage rates is not justified because the available water level elevation data indicates that the tailings embankment impedes groundwater flow (see Embankment area on Plate I, section B-B').

TABLE II
CALCULATED SEEPAGE RATES ACROSS
RICHARDSON FLATS TAILINGS EMBANKMENT
SUMMIT COUNTY, UTAH

Hydraulic Conductivity (ft/year)	Representative Medium	Calculated Seepage Across Main Embankment Area = 900 ft x 6 ft* (gallons per minute)	Calculated Seepage Across Main Embankment (gallons per day)
1	Recompacted Soil	0.0004	0.63
5	Natural Soil	0.0022	3.14
20	Recompacted Tailings	0.0087	12.57
100	Recompacted Gravel Pit Material	0.044	62.87
4,000	Tailings and Slimes	1.75	2,515

* Embankment area assumed to be main embankment area located at western margin of tailings pond on Plate I.

Evaporation Losses

Dames & Moore (1973) used a simple hydrologic budget analysis to determine evaporative losses in the impounded tailings as part of the impoundment design. Their analysis determined that 0.6 to 0.8 gpm per acre is lost to evaporation. Considering that the triangular-shaped land area located west of the embankment and Silver Creek approaches 5.5 acres in size and integrating the estimates of evaporation by Dames & Moore (1973) indicates that between 2,400 and 3,200 gallons per day is evaporated in the area where seepage losses would be expected to occur below the embankment (this analysis assumed that evaporation occurred on a diurnal basis on a cycle of 12 hours per day).

Wetland Consumptive Use

Studies summarized by Brooks and others (1998) and Holmes and others (1986) indicate that consumptive use by phreatophytes and riparian habitats ranges from 2.4 to 2.6 acre-feet per acre per year (ac-ft/ac/yr). Assuming that all of the triangular area located between the embankment and Silver Creek is covered by wetlands, and incorporating the available consumptive use data yields first-order approximations of evapotranspiration approaching 12,000 gallons per day. Examination of the available color aerial photography of the Richardson Flats area indicates that not all of this area is covered with the same type of vegetation. Considering that perhaps 20 percent of the area is covered with wetlands indicates that a reasonable range of wetlands consumptive use ranges from 2,400 to 12,000 gallons per day.

Contribution to Silver Creek

According to Pioneer Technical Services (1993) and Downhour and Brooks (1996), estimated flows in Silver Creek near Richardson Flats average 3.3 to 3.65 cubic feet per second (1,480 to 1,635 gpm). Likewise, estimated flows in the diversion ditch located along the southern margin of the tailings pond average 0.06 cubic feet per second (27 gpm; Pioneer Technical Services, 1993). Based on WESTON's initial site visit on November 24, 1998, WESTON staff estimated flows in the diversion ditch to approach 100 to 200 gpm near United Park City Mines Company Monitoring Well No. 3 (see Well Location Map Inset on Plate I). Recalling the potentiometric surface data collected in the area west of the tailings embankment indicate the water surface in Silver Creek is found at a higher elevation than the potentiometric surface measured in piezometer RT-7 located between Silver Creek and the tailings embankment, the apparent hydraulic contribution, if any, of tailings embankment seepage to surface water features is negligible.

CONCLUSIONS

The following conclusions were reached on the basis of the historic and supplemental hydrogeologic data collected in the Richardson Flats area:

- The tailings are partially saturated;
- The tailings are deposited on the naturally occurring pre-tailings topsoil;
- The organic-rich clayey pre-tailings topsoil serves as an effective confining layer;
- The shallow aquifer(s) are under confined conditions;
- Monitoring well RT-1 is apparently open to at least two shallow aquifers in an area where groundwater in the shallower aquifer flows downward to the deeper aquifer with lower hydraulic head;

  Higher or lower head?
- Groundwater flows from areas of higher hydraulic head located south of the tailings pond northward to areas of lower hydraulic head;
- Beyond seepage across the tailings embankment, there is no apparent hydraulic connection between groundwater stored in the tailings and underlying and adjacent to shallow alluvial aquifer(s);
- First-order approximations of seepage rates across the tailings embankment range from approximately 0.6 to 63 gallons per day;
- First-order approximations of consumptive use of seepage from the tailings embankment by the one to five acres of wetlands located west of the embankment range from approximately 2,400 to 12,000 gallons per day;
- Silver Creek is found at a higher elevation than groundwater stored in the shallow aquifer(s) located between the tailings embankment and Silver Creek;
- The apparent hydraulic contribution, if any, of tailings embankment seepage to surface water features is negligible;
- The artificial fill capping the tailings is low-permeability material derived from local sources and is composed of illite and kaolinite; and
- The effects of snow melt and storm water ponding in the tailings pond requires additional study.

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ATTACHMENT NO. 1
BORING LOGS

FIELD LOG OF BORING

DEPTH BELOW LAND SURFACE (feet)	GRAPHIC LOG	PROJECT: Richardson Flats R8-8505-27 — BORING NO.: RT-1 DESCRIPTION	SAMPLE INTERVAL	BLOW COUNTS/ 6 in.	COMMENTS
1.5		Topsoil - Dk. Brn, Sandy			
4.0		Dk Red-Brn Sandy, Clayey	5'-7' SS-1		
15		DK Red Brn Gravelly Sand	10-12' SS-2		
23		Pale Yellow-Brn Clay, Sandy, Water@17'			
31		DK Red-Brn Sandy Clay w/ Gravel			
32		Pal Yellow Grey Clay			
34		DK Red Brn Sandy Clay w/ Gravel			
36		Gravel, Clean, 1/4"-1/2" diam., (Water 10-15gpm)			
38		T.D. Yellow-grey, Clay			

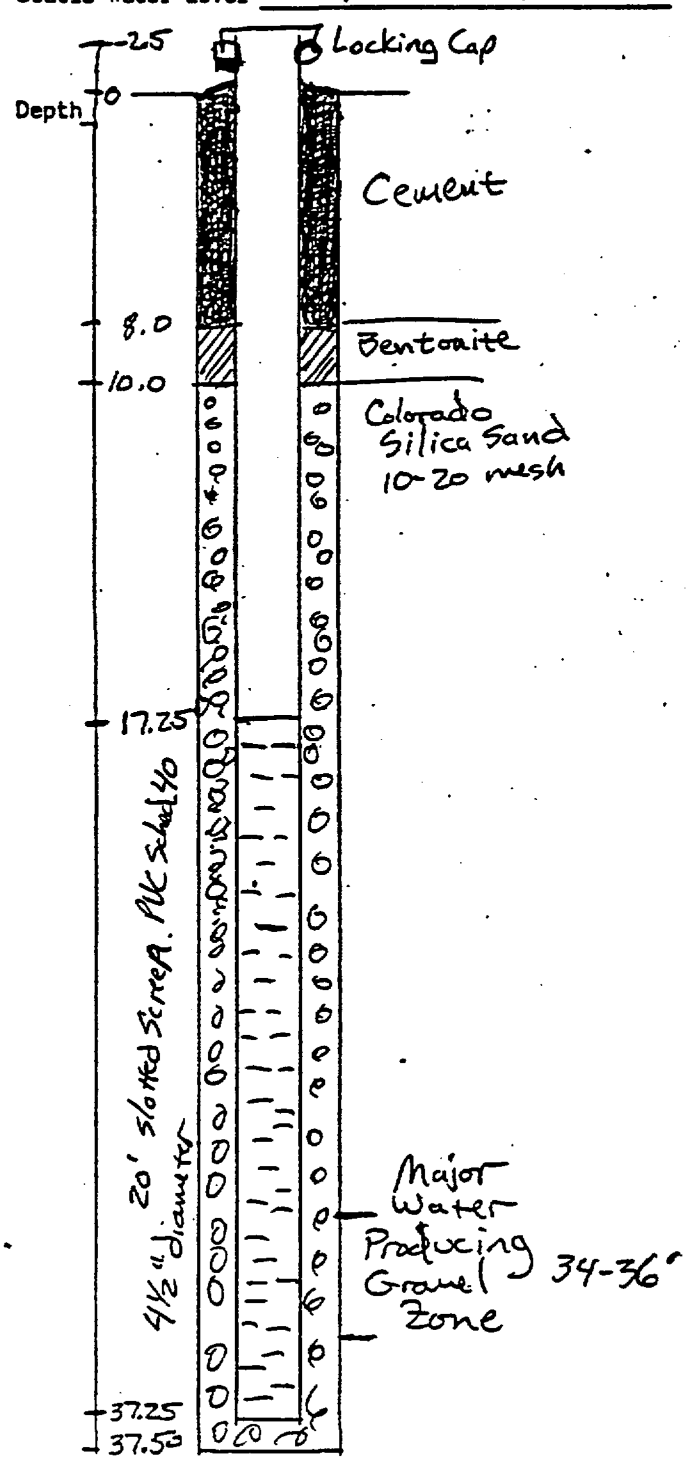
WELL/PIEZOMETER COMPLETION DIAGRAM

Piezometer Number: Well # ~~[illegible]~~ RT-1

Project: Richardson Flats R8-8505-27

Aquifer: Shallow-Alluvial

Static Water Level: ~9'



Geologist: Rob Smith

Driller: Dave's Drilling - Heber City, UT

Date of Installation: 8/1/85

Hole Depth: 37.5'

Stickup: 2.5'

Protective Casing: -2.5' to 2.5' Total 5'

Well Casing: -2.5' to 37.5' Total 40'

Top Seal

Cement from 0' to 8'

Bentonite from 8' to 10'

Hole Diameter: 7⅞"

Casing Diameter: 4½" i.d.

Well Casing Depth: 37.25

Screen Diameter: 4½" slots =

Centralizers: Top of Screen @ 17.5'

Pump Type: —

Pump Capacity: —

Pump Setting: —

Average Pumping: —

Remarks: Developed by bailing. 185 gallons purged.

PAGE ____ OF ____

DRILLING LOG

Well/Boring Number Well RT-1 (upgradient)
Project Richardson Flats Tailings
Project Number R8-8505-27
Date Started 8-1-85
Date Completed 8-1-85

Geologist Rob Smith
Driller Dave's Drilling
Geophysical Logger ——
Permit Number ——
Property Owner Park City Mines, Inc.

LOCATION

N. ____
E. ____
Elevation 6650' ± 10'

SW 1/4 of NE 1/4 of SE 1/4
Section 2 T 2S R 4E
County Summit State Utah

Drilling Method Air Rotary/Casing Drive
Samples 2 Piezometer
Rig Make and Model Chicago Pneumatic CP-7000
Drill Bit Diameter 7 7/8" (2" splitspoon sampler)

Logs
Res. SP Gam. G-Den. Neut. Calip. Dev. Sonic
Pipe dope used

DRILLING, CORING, BIT AND CASING RECORD

Diameter	Depth From	Depth To	Notes
7 7/8"	0	2	Topsoil
	2	15	Red Brn Sand
	15	23	Yell. Clay
	23	34	Red Sand
	34	38	Gravel

ADDITIVES USED

Depth From	Depth To	Additives

Notes: Two Split Spoon Samples Collected (5-7' + 10-12')
Well completed @ 38', W.L. at ~9'.

RICHARDSON FLATS
ID# UT980952840
BORINGS 1A/1B SERIES

Depth Interval (feet) From	To	Description
0	1.5	CLAYEY SILT: Moderate brown, some dusky brown organic material and fine roots, blocky.
1.5	2.3	CLAYEY SILT: Moderate brown, some dusky brown less organic material and fine roots, firm, damp.
2.3	4.6	CLAYEY SILT: Moderate brown w/ moderate orange pink mottling, stiff, dry.
4.6	4.7	SILTY SAND: Moderate brown, fine to coarse grained, loose, dry to damp.
4.7	11.7	CLAYEY SILT/SILTY CLAY: Moderate brown, 5% sand, stiff, damp to moist, moderate orange pink mottling disappears below 6 feet.
11.7	14.8	SILTY SAND: Moderate brown, fine sand to fine gravel, loose, coarsens with depth, clayey @14.3 to 14.6 feet, damp.
14.8	16	SILTY CLAY: Moderate reddish brown to moderate yellowish brown, firm to very stiff, damp to moist.
16	16.7	CLAYEY SAND AND GRAVEL: Moderate reddish brown, fine sand to fine gravel, 50% silty clay, loose, saturated.
16.7	19	SILTY CLAY: Moderate brown to moderate reddish brown, stiff, damp to moist.
19	22.2	GRAVELLY CLAY: Moderate reddish brown, sandy from 20.2 to 20.8 feet, moist to wet.
22.2	27.5	SILTY CLAY: Moderate yellowish brown, 10% fine to coarse sand, stiff, very stiff @ 25 feet, damp. Lost core from 27 to 31 feet.
27.5	33	CLAYEY GRAVEL: Gravel @ 27.5 feet based on drilling characteristics-clayey gravel from 27.5 to 33 feet.
33	34	CLAY: Yellow brown clay, stiff @ 33 to 34 feet.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 12.80 feet below ground surface on 2/2/99 in RT-1A; 12.65 feet below ground surface on 2/2/99 in RT-1B.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 16.5 to 11.5 feet; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from T.D. to 4 feet. Bentonite chips from 4 feet to ground surface.

FIELD LOG OF BORING

PROJECT: Richardson Flats R8-8505-27

BORING NO.: RT-2 (Tailings)

DEPTH BELOW LAND SURFACE (feet)	GRAPHIC LOG	DESCRIPTION	SAMPLE INTERVAL	BLOW COUNTS/ 6 in.	COMMENTS
0.8		Lt Grey, Sand, No Sulfides, Carbonate			
1.2		Grey Brown, Clay-Silt, Sulfides, Carbonate	SS-3		
1.3		Lt Grey, Sand, No Sulfides, Carbonate	Oxidized		1.0-3.5
3.5		Lt Brown, Clay Silt, Sulfides, Carbonate			
11.0		DK Grey, Sand-Silt, Sulfides, Carbonate	SS-4 red	▽12'	3.5-7.5
12.5		Lt Brn, Grey, Sand, Gravel, Carbonate + Sulfide			
14.0		Lt Grey, Tan, Coarse Sand + Gravel, Carbonate + Sulfide			
16.0		No Recovery	SS-5		
17.6		Lt Grey-Tan Coarse Sand + Gravel, Carbonate	Bottom		12-17.8 w/o ~~18~~16
17.7		DK Grey-Black, Clay, Sulfides			
18.0		DK Brn, Clay-Silt - Native Soil	SS-6 Under		17.7-18
22		Gravel - Partial Recovery			

PAGE ____ OF ____

DRILLING LOG

Well/Boring Number Boring RT-2 (Tailings)
Project Richardson Flats Tailings
Project Number 18-8505-27
Date Started 8/2/85
Date Completed 8/2/85

Geologist Rob Smith / D Tuesday
Driller — Dave's Drilling
Geophysical Logger —
Permit Number —
Property Owner Park City Mines, Inc.

LOCATION

N. ____
E. ____
Elevation 6600 ± 20

SE 1/4 of NE 1/4 of NE 1/4
Section 2 T 2S R 4E
County Summit State Utah

Drilling Method Air Rotary/Split Spoon Sampler
Samples Piezometer
Rig Make and Model Chicago Pneumatic / CP-7000
Drill Bit Diameter 6" (2" split spoon)

Logs
Res. SP Gam. G-Den. Neut. Calip. Dev. Sonic
Pipe dope used

DRILLING, CORING, BIT AND CASING RECORD

Diameter	Depth From	Depth To	Notes
6"	0	3.5	Oxidized
	3.5	12.5	Reduced
	12.5	14	Coarse Jig Tails
	16	17.7	Clay Sulfides
	17.7	22	Clay + Gravel

ADDITIVES USED

Depth From	Depth To	Additives

Notes: Four Split spoon samples taken
Hole in Tailings Pond
Grouted + Backfilled after Sampling
Wet at 12'.

RICHARDSON FLATS
EPA ID# UT980952840
BORING RT-3

Depth Interval (feet) From	To	Description
0	0.75	CLAY: Pale reddish-brown, 5% sand, some pebbles and roots, (artificial fill).
0.75	3.7	FINE SAND-TAILINGS: Light olive gray to olive gray, straited, silt, damp to moist @ 2.5 feet.
3.7	7.3	SAND-TAILINGS: Dusky yellow, dry, to increasingly damp and wet @ 6 feet.
7.3	7.8	CLAY: Grayish brown, organic rich, stiff, some roots, moist, (original topsoil).
7.8	9.8	SILTY CLAY: Moderate yellowish brown, firm to stiff, softer in places from 8 to 9.8 feet.
9.8	11	CLAYEY SILT: Grayish-orange, firm to stiff, some white finely crystallive material (kaolinite?) in fractures and pockets, dry to damp.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 4.9 feet below ground surface on 2/2/99.

(3) Plug initial hole with bentonite chips. Direct push new hole to 7 feet. Set 5 feet of 0.010-inch factory-slotted screen from 7 feet to 2 feet; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from T.D. to 1 feet. Bentonite chips to surface.

RICHARDSON FLATS

ID# UT980952840

BORING RT-4

Depth Interval (feet) From	To	Description
0	1	CLAY: Dusky yellowish brown, organic, soft, roots (artificial fill).
1	2.5	SILT-TAILINGS: Light olive gray.
2.5	5.2	FINE SAND - TAILINGS: Pale yellowish brown, well sorted, dry.
5.2	5.6	FINE SAND AND SILT-TAILINGS: Light brown to pale olive.
5.6	6.2	SILTY CLAY: Dusky brown, organic rich with roots (original top soil).
6.2	7.0	SILTY CLAY: Moderate yellowish brown to light brown, stiff, moist.
7.0	7.4	SILTY CLAY: Grayish-brown, organic rich, soft to firm, with roots, moist to damp.
7.4	8.0	SILTY CLAY: Moderate brown to light brown, stiff to very stiff.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Piezometer was found dry on 2/2/99.

(3) Set 5 feet of 0.010-inch factory slotted screen from 7 to 2 feet; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from T.D. to 2 feet. Bentonite chips to surface.

RICHARDSON FLATS

ID# UT980952840

BORING RT-5

Depth Interval (feet) From	To	Description
0	0.7	SILTY CLAY: Dusky brown, organic rich, with roots, dry (artificial fill).
0.7	7.0	FINE SAND AND SILT - TAILINGS:Pale olive, dusky yellow, some coarse roots.
7.0	9.0	FINE SAND-TAILINGS: Pale green to dark yellowish brown, damp.
9.0	10.8	FINE SAND - TAILINGS: Medium gray, damp.
10.8	11.8	SILTY CLAY: Dark yellowish brown, organic rich, firm, abundant roots, damp, wet to saturated, (original top soil).
11.8	13	SILTY SAND: Brownish gray, soft, some clay, saturated.
13	14	SANDY CLAY: Greenish-orange, firm, wet, to moist @ 14 feet.
14	15	GRAVELY SAND: Pale reddish brown, compact, silty, damp to moist - not saturated.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 7.30 feet below ground surface on 2/2/99.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 13 feet to 8 feet; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from 13 feet to 7 feet. Bentonite chips to surface.

RICHARDSON FLATS

ID# UT980952840

BORING RT-6

Depth Interval (feet) From	To	Description
0	0.8	SILTY CLAY: Dusky brown, 5-10% sand, stiff, some roots (artificial fill).
0.8	1.1	CLAYEY SILT-TAILINGS: Light olive gray, soft to firm, damp.
1.1	2.0	FINE SAND-TAILINGS: Light olive gray, dry.
2.0	2.5	SILTY SAND-TAILINGS: Light olive gray, coarse roots, damp.
2.5	6.0	FINE SAND-TAILINGS: Light olive gray to dark yellowish orange.
6.0	14.4	FINE SAND AND SILT-TAILINGS: Medium dark gray, wet.
14.4	15.6	MEDIUM SAND-TAILINGS: Greenish-gray, loose, wet.
15.6	16.0	FINE SAND-TAILINGS: Light olive gray.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 4.87 feet below ground surface on 2/2/99.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 10 to 5 feet; blank 1-inch diameter PVC casing to surface. Natural sand pack to 5 feet. Bentonite chips to surface.

RICHARSON FLATS

ID# UT980952840

BORING RT-7

Depth Interval (feet) From	To	Description
0	6	CLAY: Grayish black, organic rich, soft, spongy, abundant roots, saturated.
6	9.2	GRAVEL: Dark yellowish brown, silty, saturated.
9.2	10.5	GRAVELLY CLAY: Greenish-gray and moderate reddish brown, mottled, firm, damp to moist.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 0.0 feet below ground surface on 2/2/99.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 6 feet to 1 feet; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from T.D. to 1 foot. Bentonite chips to surface.

RICHARDSON FLATS

ID# UT980952840

BORING RT-8A/B SERIES

Depth Interval (feet) From	To	Description
0	1.2	CLAYEY SILT: Dark reddish brown, organic rich, <5% sand, dry to damp.
1.2	5.3	SILT: Light brown, with moderate orange pink mottling, some coarse roots, dry.
5.3	13.5	SILTY CLAY: Moderate brown, <5% coarse sand, stiff, increasing dampness below 5.3-feet some white material infilling fracture @7 ft; organic material @ 9.3 feet; pebbles @ 12.5 to 12.8 feet; increasingly moist and softer to 13.5, damp.
13.5	15.2	SANDY CLAY: Moderate brown to dark yellowish brown to clayey sand, dark yellowish brown fine sand @ 15.2 feet; 50% fine sand to fine gravel (quartzite and volcanic rock fragments); dry.
15.2	19	SILTY CLAY: Moderate brown, grayish brown organic material @ 16.6 feet, stiff, saturated; yields little free water from 16.6-16.9 feet; moist below 16.9 to 19 feet.
19	21.2	GRAVELLY CLAY: Moderate brown, 25-40% fine sand to fine gravel, moist to wet.
21.2	24	SILTY CLAY: Moderate brown to dark yellowish brown, stiff, w/ 5-10% fine gravel, firm to stiff, moist, moist to wet at 24 feet.
24	26	GRAVELLY CLAY-CLAYEY GRAVEL: Moderate brown, 40-50% fine sand to fine gravel, wet.
26	27	SILTY CLAY: Moderate yellowish brown, firm to stiff, moist.
27	30	SILTY CLAY: Moderate brown, 10-20% fine to coarse sand, soft, compacts easily, blockey.
30	31.7	GRAVELLY CLAY: Moderate brown, 10-20% fine to coarse sand, soft, compacts easily.
31.7	32	SILTY CLAY-CLAYEY SILT: Moderate yellowish brown, 5-10% fine to medium sand, firm to stiff, moist to wet.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 12.30 feet below ground surface in RT-8A; static water level at 12.23 feet below ground surface in RT-8B on 2/2/99.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 31 to 26 feet in RT-8B; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from 26 to 25 feet; granular bentonite to surface.
Set 5 feet of 0.010-inch factory-slotted screen from 17 to 22 feet in RT-8A; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from 22 to 16 feet; granular bentonite to surface.

RICHARDSON FLATS

ID# UT980952840

BORING RT-9

Depth Interval (feet) From	To	Description
0	1.9	SILT: Dusky yellowish brown, organic rich, occasional pebble, dry.
1.9	2.3	SILT: Moderate brown, compact, dry.
2.3	6.0	FINE SAND: Dark yellowish orange, medium gravel, silty @ 5 feet, loose, dry.
6.0	9.6	GRAVELLY SILT: Moderate yellowish brown to moderate brown, 10-20% coarse sand to fine gravel, organic rich layer @ 6.6 feet, loose to firm, dry.
9.6	10.5	SILTY GRAVEL: Moderate yellowish brown, loose, dry.
10.5	11	GRAVEL: Very pale orange, coarse, dry.
11	13.2	GRAVELLY SILT: Moderate yellowish brown, silty gravel, medium sand to medium gravel.
13.2	15.4	GRAVELLY SILT: Moderate reddish brown to dark reddish brown, dry.
15.4	16.0	GRAVELLY SILT: Dark yellowish brown, loose, dry.
16.0	21.8	SILTY GRAVEL: Moderate yellowish brown, saturated and sandy at approximately 19.75 to 21.8, cobble @ 17 feet, then sharp contact and dry below.
21.8	23	GRAVEL: Moderate reddish brown, silty, clayey, moist.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 18.03 feet below ground surface on 2/2/99.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 23 to 18 feet; blank 1-inch diameter PVC casing to surface. 10x20 sand pack from T.D. to 17 feet. Bentonite chips from 4 feet to ground surface.

RICHARDSON FLATTS

EPA ID# UT980952840

BORING RT-10

Depth Interval (feet) From	To	Description
0	2.1	CLAY: Black, organic rich, soft to firm, plastic, moist.
2.1	2.8	SILTY CLAY: Dusky yellowish brown, with 15% medium to coarse sand, firm, damp.
2.8	3.6	SANDY SILT: Dark yellowish brown to moderate yellowish brown, 25 to 40% fine sand, some clay, damp to moist.
3.6	6.3	SILTY SAND: Moderate yellowish brown, loose, well sorted, some coarse sand @ 6.3 feet, increasingly saturated with depth.
6.3	6.6	CLAY: Pale yellowish brown, firm plastic, wet.
6.6	8.0	SILTY SAND: Pale yellowish brown, loose, fine to medium sand, saturated.

NOTES:

(1) Color description corresponds to the Geological Society of America Rock Color Chart (1991).

(2) Static water level at 1.1 feet below ground surface on 2/2/99.

(3) Set 5 feet of 0.010-inch factory-slotted screen from 8 feet to 3 feet, blank 1-inch diameter PVC casing to surface. 10x20 sand pack from 3 to 2 feet; granular bentonite chips to surface.

ATTACHMENT NO. 2
X-RAY DIFFRACTION DATA

Analysis of Soil Samples/United Park City Mines Company

Prepared for: Weston Engineering, Inc.
P.O. Box 6037
Laramie, WY 82072
(307) 745-6118

Sample shipped from Park City, UT

Prepared by: Dr. Norbert Swoboda-Colberg
Dept. of Geology & Geophysics
University of Wyoming
P.O. Box 3006

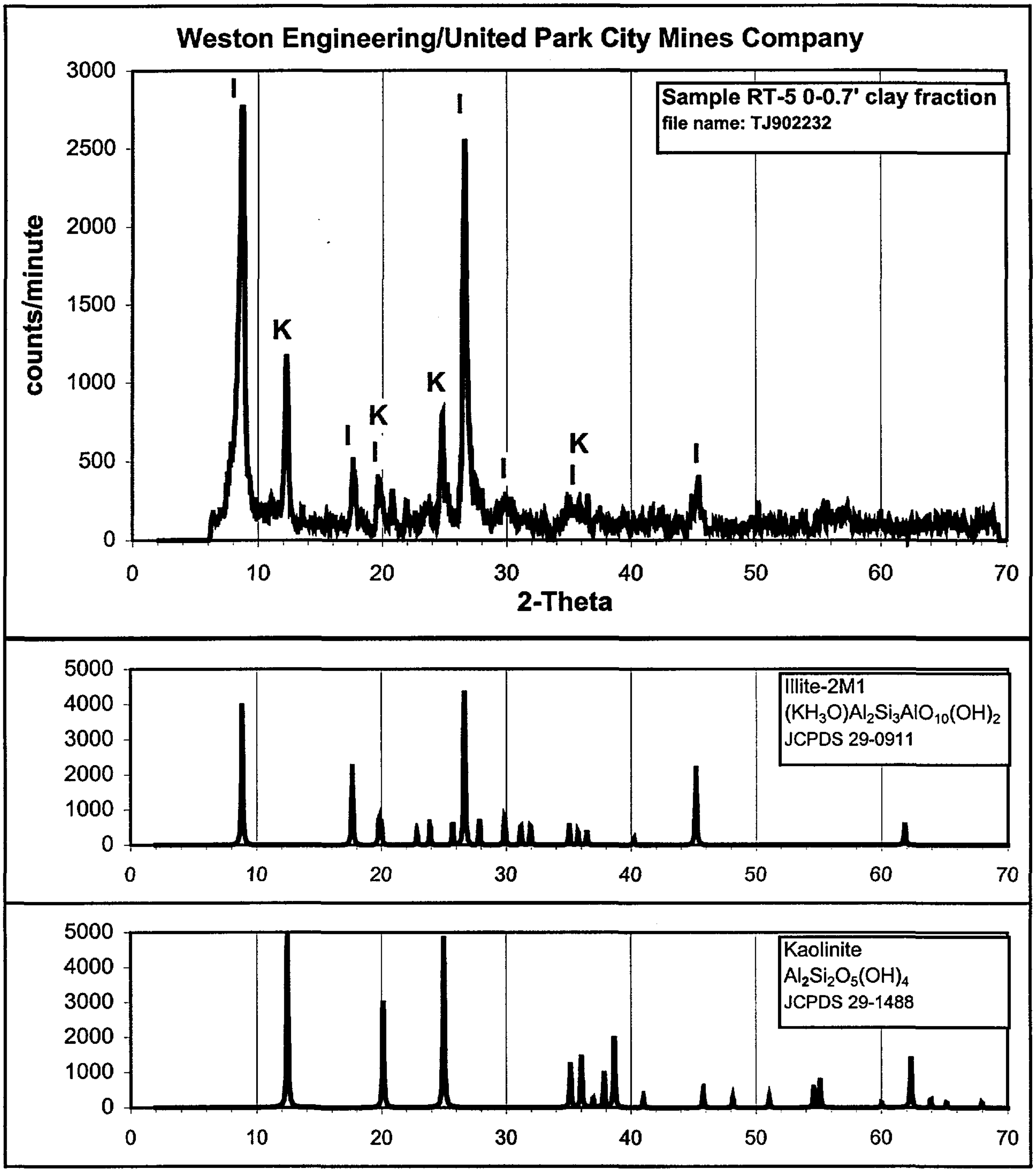
Samples: Boring RT-5, 0-0.7 feet
Boring RT-5, 11 feet
Boring RT-5, 13.5 feet
Sampled at Park City, UT on 2/15/99
Ref.: Bill Loughlin

Sample Prep.: Samples were treated according to standard procedures for clay analyses in soils. Samples were treated with peroxide (removal of organic material) and size fractionated to enrich clay fraction.

Summary: The two deeper samples (11 and 13.5 feet) were visually very different; the sample from 11 feet depth was relatively organic rich soil, while the sample from 13.5 feet was mostly made up of clay and silt. However, the two samples are very similar in the composition of their clay fraction. In both samples the clay fraction consists of sepiolite, a magnesium silicate, and calcite (calcium carbonate).

The surface sample (0-0.7 feet) has a clay composition which is completely different from that of the deeper samples. In the surface sample, the clay fraction is made up of illite (a potassium aluminum silicate) and kaolinite (an aluminum silicate).

Special Note: Sepiolite, the clay mineral identified in the deeper samples, is a relatively rare clay mineral and would not be expected to be found in the Park City area, although it is not entirely impossible. The characteristic peak at a d-spacing of 12Å does not match any other "simple" clay minerals. However, it is possible that the clay identified as "sepiolite" is in fact a rather ill-defined mixed-layer clay mineral (mixed mica and illite or smectite, for example) which can be found in relatively immature soils on granitic bedrock. The distinction cannot be made without further analysis.



Weston Engineering/United Park City Mines Company
Sample RT-5 0-0.7' clay fraction
file name: TJ902232
counts/minute
2-Theta
I
K
I
K
I
K
I
I
K
I
I
0
500
1000
1500
2000
2500
3000
0
10
20
30
40
50
60
70
Illite-2M1
(KH3O)Al2Si3AlO10(OH)2
JCPDS 29-0911
Kaolinite
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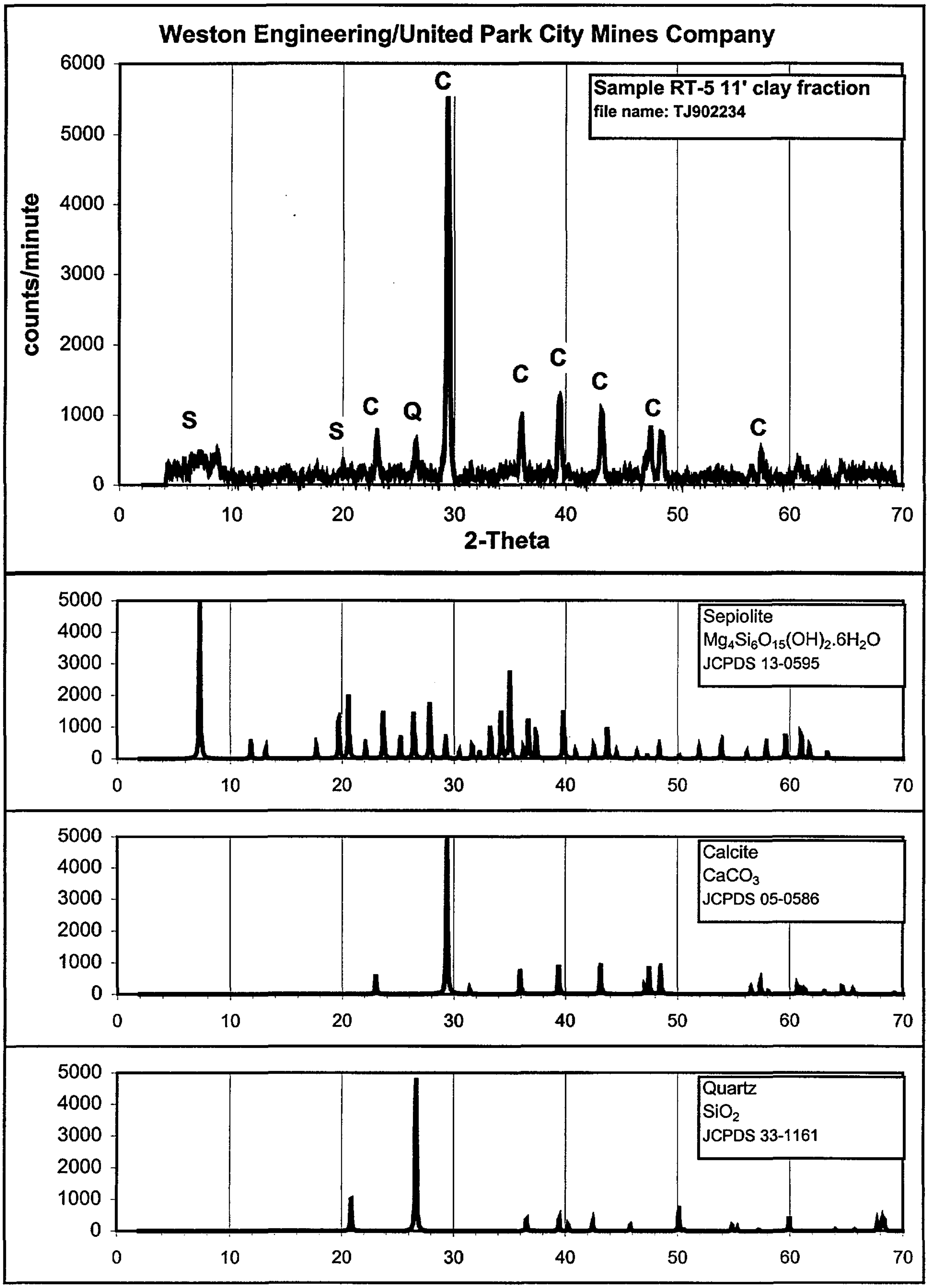
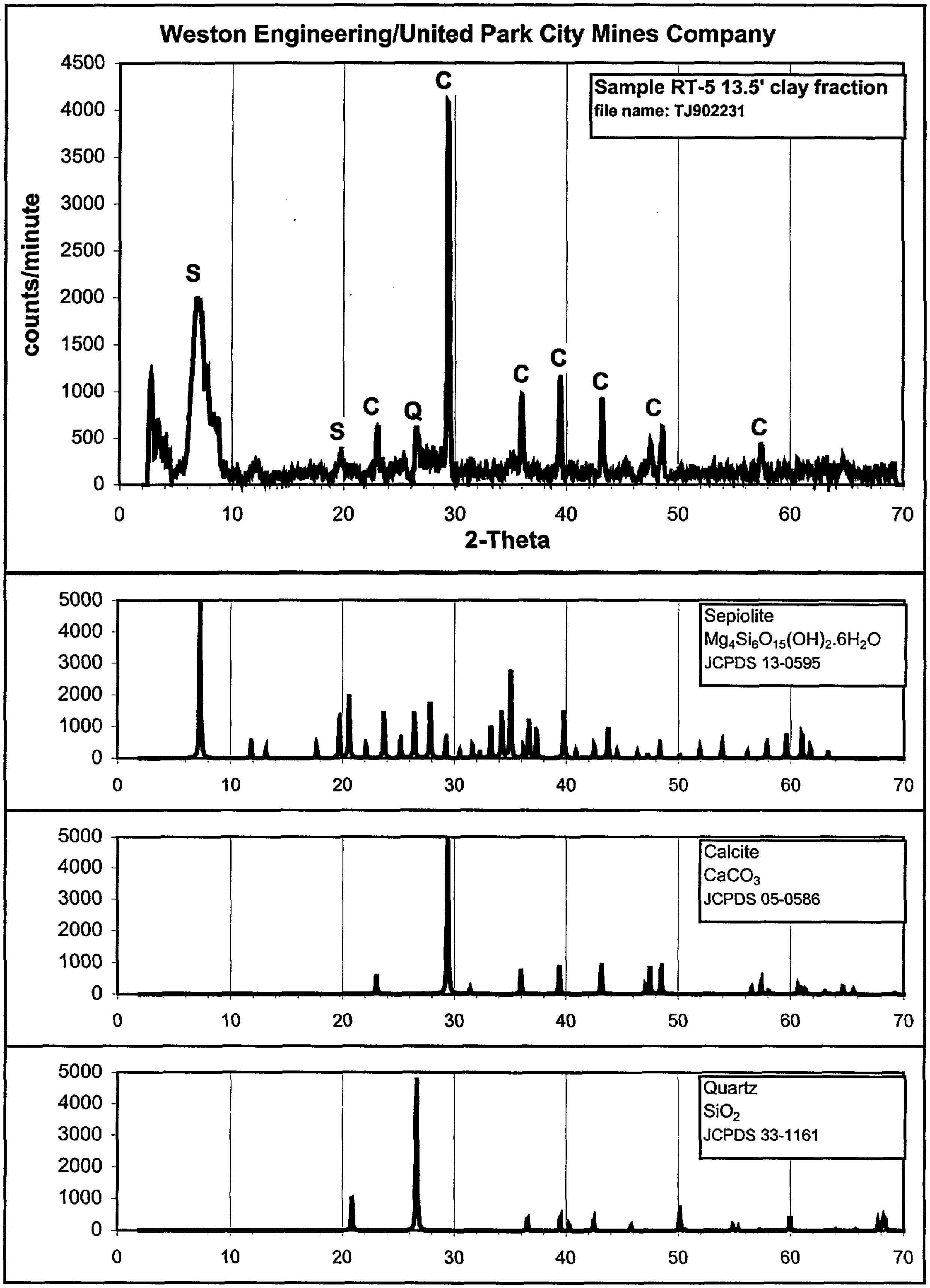


Weston Engineering/United Park City Mines Company
Sample RT-5 11' clay fraction
file name: TJ902234
counts/minute
2-Theta
S
S
C
Q
C
C
C
C
C
C
Sepiolite
$Mg_4Si_6O_{15}(OH)_2.6H_2O$
JCPDS 13-0595
Calcite
$CaCO_3$
JCPDS 05-0586
Quartz
SiO_2
JCPDS 33-1161



Weston Engineering/United Park City Mines Company
Sample RT-5 13.5' clay fraction
file name: TJ902231
counts/minute
2-Theta
S
S
C
Q
C
C
C
C
C
C
Sepiolite
$Mg_4Si_6O_{15}(OH)_2.6H_2O$
JCPDS 13-0595
Calcite
$CaCO_3$
JCPDS 05-0586
Quartz
SiO_2
JCPDS 33-1161

ATTACHMENT NO. 3
ARTIFICIAL FILL CAP PERMEABILITY DATA

Applied Geotechnical Engineering Consultants, Inc.

January 12, 1999

Confidential and Privileged: Attorney-Client and Work Product Privilege

LeBoeuf, Lamb, Greene & MacRae, L.L.P.
100 Kearns Building
136 South Main Street
Salt Lake City, UT 84101

Attention: Brad Merrill

Subject: Permeability Testing
United Park City Mines/Richardson Flats Property
Summit County, Utah
Project No. 983806

Gentlemen:

Applied Geotechnical Engineering Consultants, Inc. was requested to test the soil for classification and permeability on the Richardson Flats property in Summit County, Utah.

FIELD SAMPLING

On December 2, 1998, a representative of AGEC visited the site and tested the soil in its in situ condition for moisture content and dry density. Listed below is a summary of the approximate locations and the in-place moisture content and dry density:

Location No.	Location	Moisture Content (%)	Dry Density (pcf)
1	Main Embankment West	27.5	87.7
2	West Central	26.7	88.7
3	North Central	27.7	88.5

Samples were obtained of the soil immediately beneath the area tested for moisture content and density. These samples were returned to the laboratory for classification testing. The samples are classified as lean clay with sand. The laboratory test results are summarized on Figures 1, 2 and 3.

PERMEABILITY TESTING

Two of the samples were remolded in the laboratory to their in-place moisture content and density. The samples were then tested in a triaxial permeameter to determine the permeability. Listed below is a summary of the laboratory test results:

Sample No.	Sample Location	Permeability (cm/sec)
2	West Central	7×10^{-8}
3	North Central	3×10^{-8}

These two samples were tested with the anticipation that they would provide the boundaries of the highest and lowest of the three samples obtained.

If you have any questions or if we can be of further service, please call.

Sincerely,

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

James E. Nordquist, P.E.

JEN/js

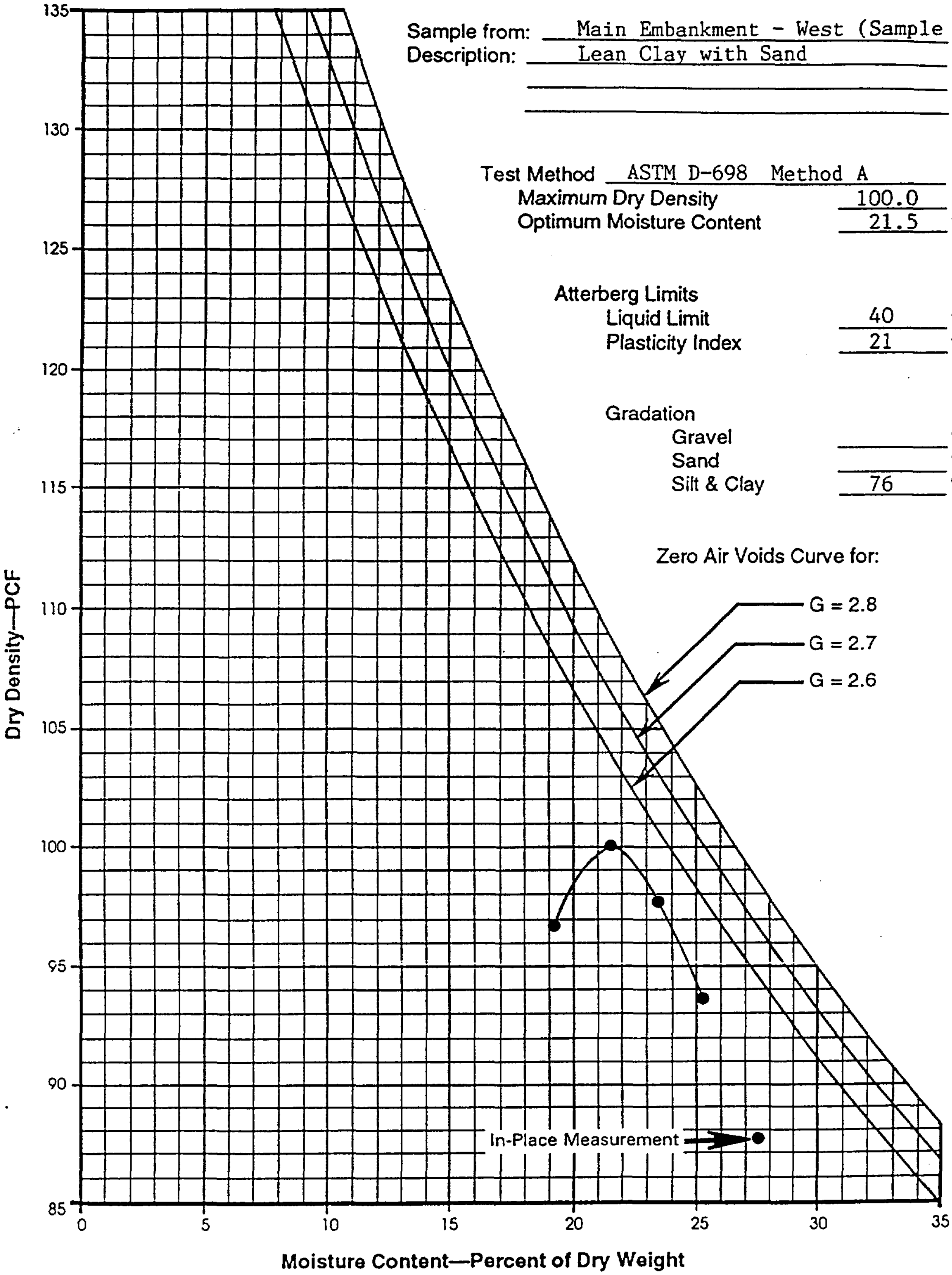
Applied Geotechnical Engineering Consultants, Inc.

Sample from: Main Embankment - West (Sample #1)
Description: Lean Clay with Sand

Test Method ASTM D-698 Method A
Maximum Dry Density 100.0 pcf
Optimum Moisture Content 21.5 %

Atterberg Limits
Liquid Limit 40 %
Plasticity Index 21 %

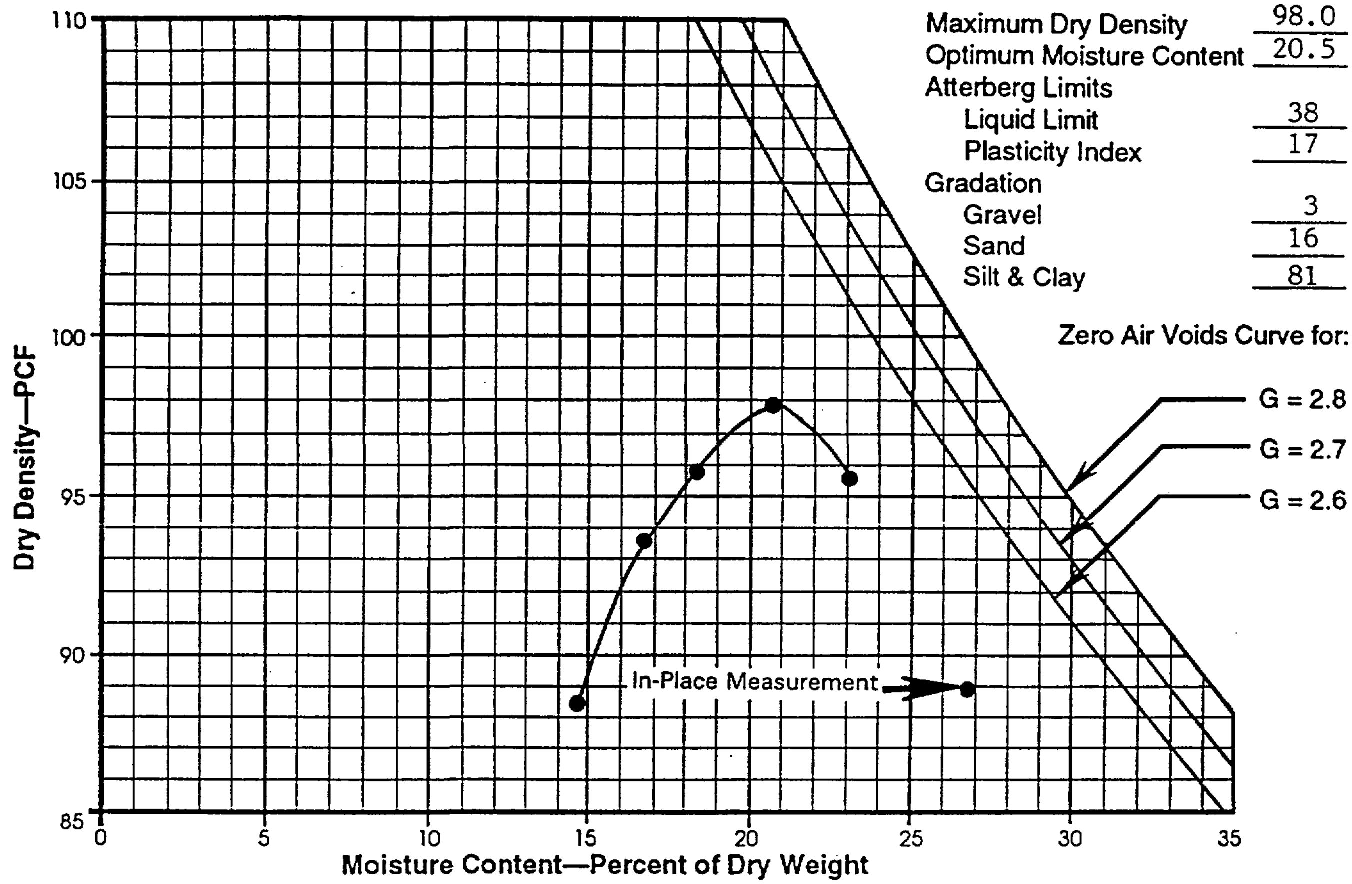
Gradation
Gravel %
Sand %
Silt & Clay 76 %



Project No. 983806 **COMPACTION TEST RESULTS** Figure 1

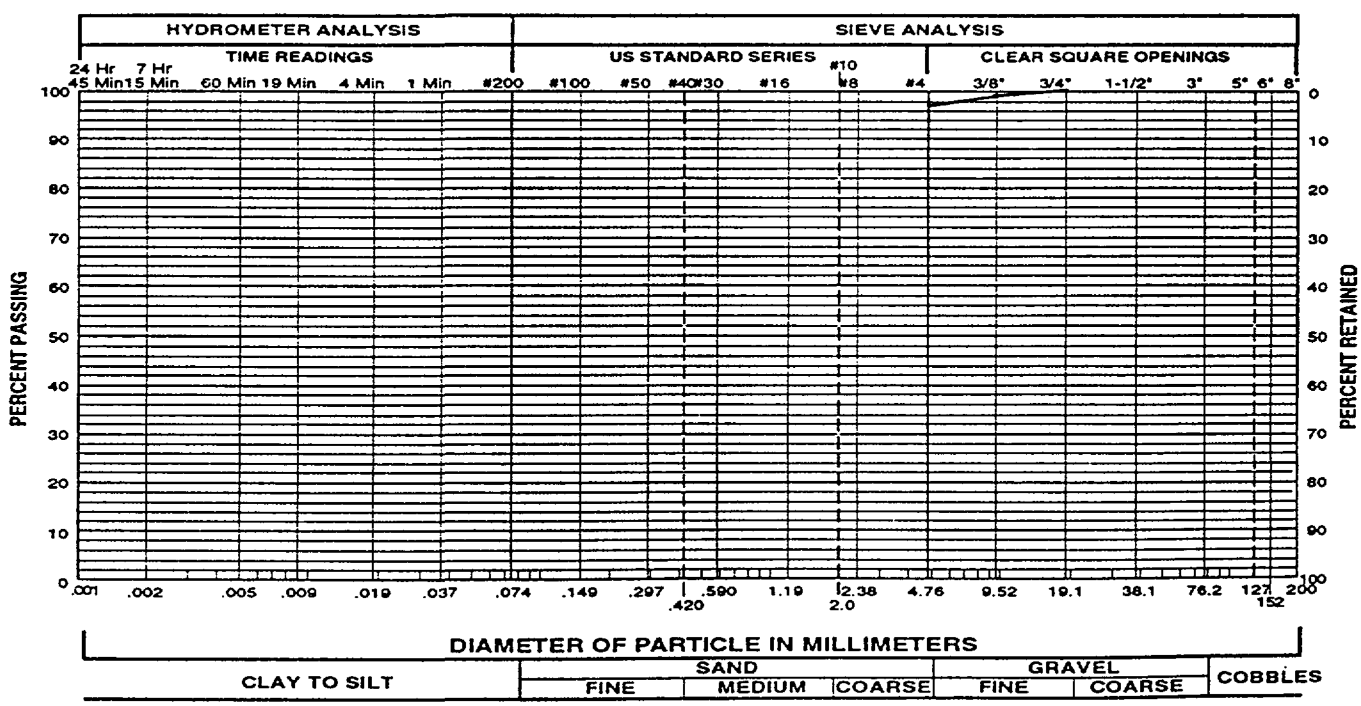
Applied Geotechnical Engineering Consultants, Inc.

Maximum Dry Density	98.0	pcf
Optimum Moisture Content	20.5	%
Atterberg Limits		
Liquid Limit	38	%
Plasticity Index	17	%
Gradation		
Gravel	3	%
Sand	16	%
Silt & Clay	81	%



Compaction Test Procedure ASTM D-698 Method A

Sample of: Lean Clay with Sand From: West Central (Sample #2)



GRADATION & COMPACTION TEST RESULTS

Project No. 983806

Figure 2

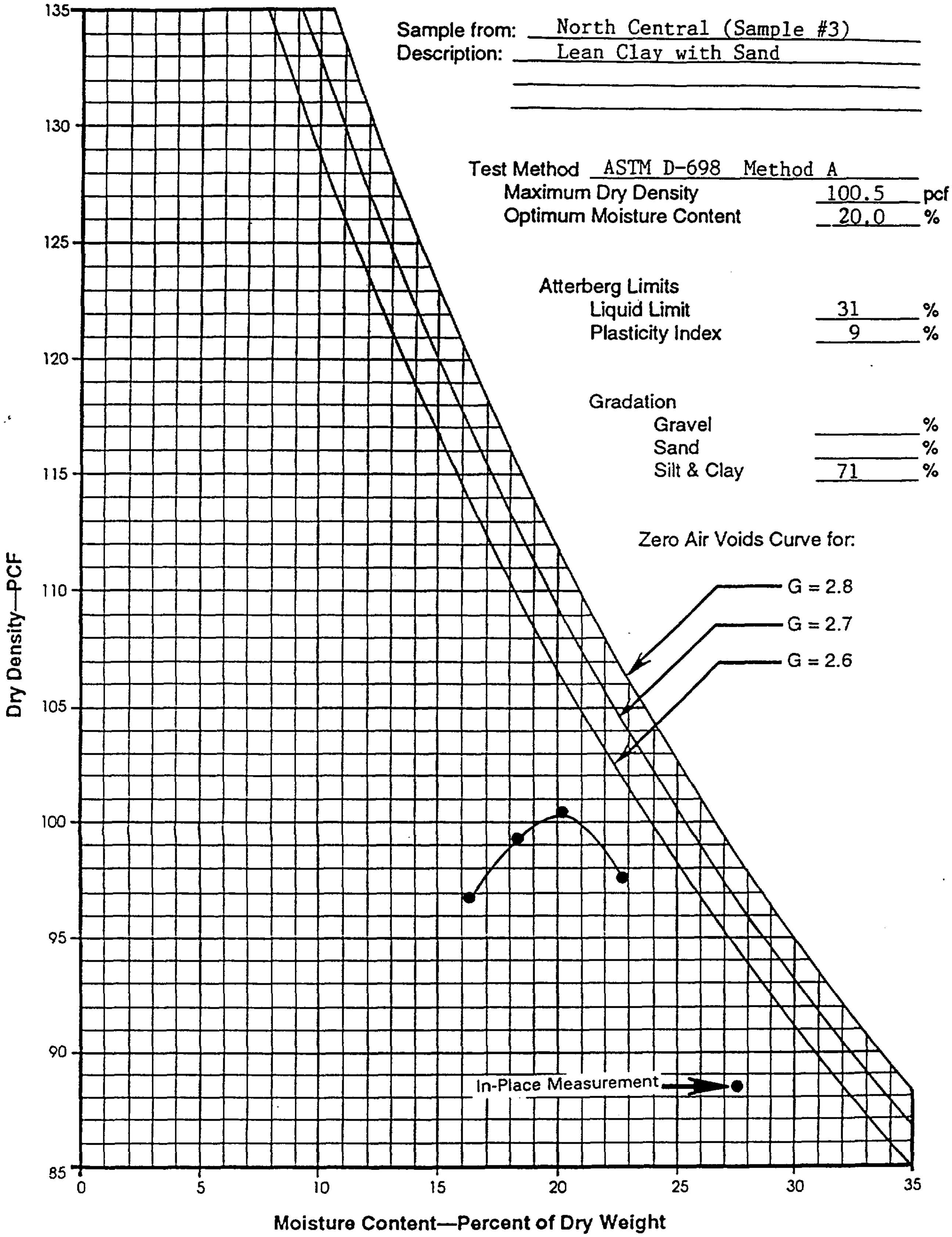
Applied Geotechnical Engineering Consultants, Inc.

Sample from: North Central (Sample #3)
Description: Lean Clay with Sand

Test Method ASTM D-698 Method A
Maximum Dry Density 100.5 pcf
Optimum Moisture Content 20.0 %

Atterberg Limits
Liquid Limit 31 %
Plasticity Index 9 %

Gradation
Gravel ____ %
Sand ____ %
Silt & Clay 71 %



Project No. 983806 **COMPACTION TEST RESULTS** Figure 3

EPA REGION VIII
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOC ID # 453278
PAGE #

IMAGERY COVER SHEET
UNSCANNABLE ITEM(S)

Contact the Superfund Records Center to view this (these) document(s).
(303-312-6473)

SITE NAME: Richardson Flats

REPORT OR DOCUMENT TITLE: Preliminary Hydrogeologic Review of Richardson Flats Tailings Site Sections 1 + 2 township 2 south Range 4 East Summit County Utah

DATE OF DOCUMENT: 01-Mar-99

DESCRIPTION OF IMAGERY: 1 oversized map